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Dialysis costs: Results of a diverse sample study

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Dialysis costs: Results of a diverse sample study. A study of dialysis costs in five major dialysis centers throughout the United States was conducted in 1973. When available, home, home training, limited care, satellite and in-hospital-full-care dialysis were included. The study's objective was to determine the cost per dialysis for each separate dialysis modality. All costs associated with the dialysis procedure were included. Using a uniform methodology, costs were collected on four care levels which vary significantly from each other in the use of direct labor. They are as follows: home, home care training, limited care and full care. Costs were also segregated into five expenditure categories: personnel, supplies, travel, equipment and other. The study was designed to show the range of costs in five "representative" centers throughout the country, but not to provide statistical "average" of dialysis costs. Cost per dialysis ranged from $33 to 66 for the home patient group, $100 to 116 for limited care, $144 to 172 for in-hospital and $146 to 259 for the home training units.

Coût de l'hémodialyse. L'étude des coûts de l'hémodialyse dans cinq centres importants des Etats Unis a été réalisée pour l'année 1973. Les diverses modalités de dialyse (à domicile, entraînement à domicile, avec assistante limitée, satellite et dialyse avec assistance totale en milieu hospitalier) ont été incluses chaque fois que cela était possible. L'objectif de ce travail est de déterminer le coût de chacune des modalités de dialyse. Au moyen d'une méthodologie uniforme, les coûts ont été déterminés à quatre niveaux de soins qui diffèrent significativement les uns des autres par le travail utilisé. Ce sont: la dialyse à domicile, l'entraînement à domicile, l'assistance limitée et l'assistance totale. Les coûts ont été séparés en cinq catégories de dépenses: personnel, matériel consommable, déplacements, équipement et divers. Le but de l'étude est de classer les ordres de coûts dans cinq centres représentatifs de l'ensemble du pays, mais non de donner une moyenne statistique des coûts de dialyse. Le coût par dialyse varie de 33 à 66 (US) dollars dans le groupe des patients à domicile, de 100 à 116 pour l'assistance limitée, de 144 à 172 en milieu hospitalier et de 146 à 259 pour les unités d'entraînement à domicile.

The Artificial Kidney-Chronic Uremia Program of the National Institute of Arthritis, Metabolism, and Digestive Diseases (NIAMDD) has the responsibility within the National Institutes of Health for sponsoring dialysis-related research. To provide a data base for research planning, the Program conducted a detailed study of dialysis costs in a diverse sample of typical units, in the United States. This report is a summary of that study. In June, 1973, five major dialysis programs agreed to enter the study. The NIAMDD retained the services of the Nephrology Cost Group[1] (NCG) to monitor the study, maintain uniformity and analyze the results.

The study was designed to show the range of costs in five "representative" programs throughout the United States but was not designed to provide a statistical "average" of dialysis costs. To accomplish the objective it was necessary to define various locations and modalities of dialytic therapy and generate the cost per dialysis for each modality. The data can be used to generate weekly, monthly and annual costs for any particular modality.

Traditionally, in describing dialysis therapy, four care levels are used which vary significantly from each other in the intensity and cost of direct labor. Often these levels vary significantly with the stability of the patient, and his involvement in his treatment. These levels are as follows: home, home dialysis training, limited care and in-hospital. Participating hemodialysis programs offered these levels of care and in some cases, "satellite" dialysis. The study data are presented using these traditional definitions.

Unfortunately, the definition of these levels or classes of dialysis care is imprecise. They confuse

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[1]The Nephrology Cost Group is composed of professional administrators with extensive experience in the administration of hemodialysis units as well as all other aspects of health care delivery for end-stage renal disease patients. Mr. Paul A. Hoffstein, the President of the Nephrology Cost Group, is the Assistant Dean for Planning at the University of Texas Medical School at Houston and formerly Branch Chief, Technical Development Branch, Division of Kidney Disease for the U.S. Department of Health, Education and Welfare. Two of the three other members of the Nephrology Cost Group who were involved in this project are administrators of hemodialysis units, each with over three years' experience with end-stage renal disease care experience. The third person is an accountant with experience in hemodialysis cost information systems.

two factors: (*1*) the degree of patient participation in his or her care, and (*2*) the physical location of the care. Often, a location and medical treatment philosophy will contradict each other. Many out-of-hospital limited care units provide as full care as an in-hospital unit. Others offer self-care, similar to home dialysis. For convenience and ease of understanding the normal definitions have been retained. However, another group of definitions is offered for future use:

Level of care. (*1*) *Self-care.* The patient alone, or with a nonprofessional helper (often a family member) provides all of the technical care. The patient is medically stable. (*2*) *Partial care.* The patient has been taught to perform some of the treatment tasks. The patient, usually alone, but possibly with a helper, participates actively in treatment but does not need to perform all of the tasks. Support is offered by the staff commensurate with the patient's need. The patient is usually medically stable. (*3*) *Full care.* All technical assistance to perform dialysis is provided by the personnel in the facility. The patient does not perform any measurable duties. The patient need not be stable. (*4*) *Intensive care.* This level of care is more extensive than a routine dialysis treatment and involves a higher personnel to patient ratio, a higher degree of physician supervision and usually registered nurses. The patient is unstable. The patient does not assist in his or her care. (*5*) *Self-care training.* This is a process of teaching/training and treating patients to be able to perform unassisted dialysis, i.e., alone or with the assistance of a nonprofessional helper. Self-care training is predicated upon stable patients performing much of the treatment alone or with the future self-care helper.

Location and organizational relationships. (*1*) *Center.* A kidney disease center usually supervises other dialysis units. The center provides the range of services necessary to maintain patients on intermittent dialysis. The center personnel often screen and select patients, select treatment modalities, provide intensive care, etc. The center often trains or retrains personnel for the affiliated units. (*2*) *Affiliated.* The facility does not provide the full range of services necessary for all types of patients being maintained on intermittent dialysis and depends on an integrated hospital center for referral of patients, staff training, medical assistance, etc. The affiliated unit often refers patients back to the center when problems occur. (*3*) *In-hospital.* Treatment takes place within a hospital building. (*4*) *Out-of-hospital.* Treatment does not take place in a hospital building.

Methods

In the past, other reports [1–7] concerning the cost of dialysis have been attacked for being incomplete or biased or both. Complaints of inconsistency were often used to cast doubt on an entire study. Accordingly, in this study every effort has been made to use uniform methodology. A uniform chart of accounts specifically for hemodialysis programs was developed. This chart of accounts was based on the American Hospital Association chart of accounts which was expanded to provide the necessary detail to assure consistent results. All expenditure categories were extensively subdivided, defined and cataloged. A companion set of reporting instructions was provided to each center, which spelled out the form of data submission and the boundaries of the study. Unlike many previous studies, the centers in this study had multilocations and multitreatment programs which tended to minimize any philosophical bias in the study.

Raw data from each study location were tabulated in a standard format. The first step in analysis involved regrouping the data by major classifications. Further simplification provided a less detailed summary which is presented in this report.[2] The boundaries set for the study depended on the particular dialysis program but included, when available, home, home-training, limited care, satellite and in-hospital full-care dialysis. Acute dialysis and pretransplant and posttransplant dialysis were specifically excluded.

All costs irrespective of source associated with the dialysis procedure were included. Reportable costs included cash outlay and expenditures made by the provider or the patients. Also included were the fair market value of goods or services funded by donation or grant. Costs of the dialysis treatment were based on use or effort and not based on issuance, delivery, payment and the like. A point of emphasis is that the study was of dialysis *costs* not *charges* for any component. The original scope of the study was intended to include all costs associated with normal intermittent hemodialysis, including costs of physician services, blood access surgery and radiology services. The scope of the study was *not* intended to include the costs of any medical complications arising as a result of dialysis or the patient's other medical conditions. Within the resources of the study, however, it was not possible to collect reliable cost data on physician services, radiology and blood access surgery, so these factors were excluded.

The study presented a quantitative, but not qualitative, evaluation of dialysis. The study did not address the issue of quality of care, quality of personnel

[2]The complete, detailed data from the study, the chart of accounts and reporting instructions have been deposited with the National Technical Information Service. Requests should be addressed to National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151, U.S.A. Citing Report No. AK-1-NIH-C-222, PB 245805A/S, $8.75 paper copy, $2.25 microfiche.

and/or the quality of the equipment. Major centers which were considered reasonable models in their field were chosen, representing varied methodology, philosophy and patient population.

The study utilized the professional judgment of members of the Nephrology Cost Group and the NIAMDD to test the reasonableness of all data. The study was not a certified audit in the normal accounting sense. The study accounted for incorrect and omitted data due to deficiencies in the accounting systems, when this was possible, and in most cases corrected these deficiences, with proper notation. Data were collected within a limited time-frame during a five-month period.

One purpose was to determine costs in the same program for dialyses performed in different locations (i.e., home, limited care, hospital, etc.) to avoid some of the drawbacks of comparing data between modalities with other centers. In all cases, the statistical base number of dialyses was sufficient to get a reproducible average cost per dialysis.

The programs were geographically dispersed, the patients came from both urban and rural settings and the locations of the therapy—home, limited care, satellite and in-hospital—were distributed similar tǫ the total United States. In all programs there were approximately equal numbers of men and women. Different philosophies of administering therapy were included and a variety of major dialysate delivery systems and artificial kidneys were represented. The total patient load during the study period was approximately 550 patients or approximately 5½% of the national total. During the period when data were collected, 13,655 dialyses (equivalent to 87 patient years) were performed. All centers prescribed dialysis three times a week with durations ranging from five to eight hours, with the predominant time being six hours.

Program A is a dialysis center serving a major northeastern metropolitan area. It provides hemodialysis services in the hospital, in an out-of-hospital limited care unit, as well as home dialysis training and home dialysis. Presented in this study is only the limited care dialysis program which can be classified as a full-care out-of-hospital unit. Eighty-three patients were receiving hemodialysis during the study.

Program B is located in the south central portion of the country and serves all of the eastern half of one state and portions of adjacent states. The principal unit is a freestanding limited care unit located near the in-hospital unit. In this program, home dialysis made up the modality of 54% of the patients and 30% were in the limited care program.

Program C, also in the south central portion of the country, serves essentially an entire state. Home dialysis is the predominant modality (51% of the patients). An in-hospital program (full care) serves 30% of the patient population. A smaller percentage is served through a very comprehensive, self-care satellite program.

Program D is an out-of-hospital dialysis center which serves the western part of a northwestern state. Services provided include in-hospital, in-center, home training, and home hemodialysis and peritoneal dialysis. Dialysis modes considered in the present study are in-hospital, home training and home hemodialysis. Over 200 end-stage renal patients were being treated by dialysis, of whom 78% were at home, and 12% were in the center.

Program E serves three north central states as well as portions of two other adjacent states. Hemodialysis is provided at nine small in-hospital, full-care, satellite facilities throughout the region, as well as home dialysis, a large full-care out-of-hospital unit, an in-hospital unit and a home training unit. At the time of the study, approximately 200 patients were served.

Results

The data of the study are summarized in eight tables. The data are divided into five expense categories: personnel, supplies, travel, equipment and other accounts. It should be reemphasized that the data are not to be considered a statistically valid sampling of all dialysis operations in the United States. Rather, the data are representative of the costs of a variety of dialysis modalities at several locations. In the tables which follow, costs for each category are given in terms of the common denominator, dollar cost per dialysis.

Personnel. Cost data for direct personnel are shown in Table 1. Reported are costs for the following: (*1*) direct patient care: nurse, registered; nurse, other; technician; (*2*) other patient care: occupational therapist, social worker, financial counselor, dietician, psychiatrist/psychologist, teaching personnel—training of nonpatients; and (*3*) administration: data collection, financial administration, accounting, public information, and clerical aide to physicians. In-

Table 1. Personnel: Cost per dialysis in dollars

	Program				
	A	B	C	D	E
Home patient group	—	1.68	3.97	6.59	12.44
Limited care unit	41.86	32.26	—	—	35.89
Satellite unit(s)	—	20.34	6.81	—	54.83
In-hospital unit	—	—	72.60	58.50	74.45
Home training unit	—	58.41	101.91	107.82	132.47

Table 2. Personnel: Selected man-year-equivalents per 1,000 dialyses

	Programs				
	A	B	C	D	E
Home patient group					
Direct patient care		0.53	1.67	0.64	2.56
Other patient care	—	0.36	0.29	0.09	1.64
Administration		0.01	0.11	0.10	2.07
Limited care unit					
Direct patient care	16.07	19.55			15.13
Other patient care	0.56	0.86	—	—	0.93
Administration	0.88	1.06			2.04
In-hospital unit					
Direct patient care			45.04	25.50	34.30
Other patient care	—	—	2.91	0.84	0
Administration			0.73	0.78	0.91
Home training unit					
Direct patient care		24.59	43.23	87.95	68.18
Other patient care	—	2.84	4.68	2.88	2.47
Administration		2.64	7.58	1.35	3.51

direct personnel costs are included in the "other" cost category because the degree of comparability between centers begins to deteriorate for these costs. As noted above, the effort by nephrologists was also excluded from the personnel section and Table 1.

Table 1 is derived by dividing the total cost of the item by the number of dialyses performed during the study period. Personnel varied significantly with the location of the treatment. The home program had decidedly the lowest cost, about $7 per dialysis. Limited care in the three centers had costs that averaged $37 per dialysis. The satellite units differed appreciably; for example, Program C's satellite program was predominantly self care with minimal personnel costs.

The in-hospital program was expensive and the mean of $69 was almost twice that of the limited care program and eleven times more expensive than the home program. Home training, an intensive treatment, had the highest cost with a mean of about $100. The in-hospital and home training sections usually contained nonpatient training expenses. Personnel training usually included personnel for the center and affiliated programs. The cost of training personnel is one difference between a center and an affiliate program.

Table 2 presents selected man-year equivalents utilized by the various programs for the different modes of dialysis. These are tabulated in terms of man-year equivalents per 1000 dialyses. With respect to staffing patterns, it is interesting to note that the man-year equivalents utilized for limited care dialysis showed the least variance, i.e., the ratio of largest to smallest man-year equivalents per 1000 dialyses was 1.2 (see Table 2). Differences between in-hospital dialyses show a ratio of 1.8. Both home training and home dialysis show wider differences in levels of staff utilized, varying by a ratio of 3.1 for home training to 7.6 for personnel utilized in home dialysis.

Supplies. Supplies in the context of this cost study include (*1*) office and administration supplies, (*2*) direct dialysis supplies (related to the treatment procedure) and (*3*) other supplies. The following direct dialysis supplies made up 68 to 99% of the cost per dialysis of supplies: disposable artificial kidneys, dialysate, tubing sets, syringes and needles, i.v. administered fluid, drugs, blood, treated water and others. Supply costs not shown in this section included expendable supplies used in a core laboratory. Table 3 shows the cost for supplies in each of the programs; the primary dialyzer used is shown as a footnote.

For the home dialysis group using Kiil dialyzers, supply costs ranged from $16 to 20. Use of disposable hollow fiber or flat plate dialyzers by home patients resulted in supply costs from $29 to 48. No data were collected on home use of coil-type dialyzers.

The limited care units had an average supply cost of about $30. Program E, exclusively using Kiil kidneys had a cost of $24.78, which is over one-third greater than their cost for a Kiil home dialysis. Program B's average costs were $31.81 with 93% of the

Table 3. Supplies: Cost per dialysis in dollars[a]

	Program				
	A	B	C	D	E
Home patient group	—	19.88	17.82	18.34	**K D** G 29.13
		K 19.88	K 17.82	**K** 16.35	
				D 30.49	
				G 48.26	
Limited care unit	C 32.46	**K D** 31.81	—	—	K 24.78
Satellite unit(s)	—	K 34.32	K 26.05	—	D 38.61
In-hospital unit	—	—	K 34.99	**D** G 54.92	**K** G 37.93
Home training unit	—	**K D** 33.77	K 26.27	D 29.83	D 52.09

[a] K, Kiil; C, coil; D, Cordis-Dow (CDAK); G, Gambro. Bold type denotes predominant dialyzer. Line one is a weighted average.

Table 4. Travel: Cost per dialysis in dollars

	Program				
	A	B	C	D	E
Home treatment group	—	1.23	0.84	0.99	4.89
Limited care unit	5.35	12.10	—	—	3.11
Satellite unit(s)	—	2.60	4.08	—	10.27
In-hospital unit	—	—	14.02	5.49	3.33
Home training unit	—	21.20	12.29	3.47	15.28

patients using Kiil dialyzers and only 7% using a Cordis-Dow hollow fiber kidney. Program A is the only program using coil kidneys (Travenol and Extracorporeal units) with supply costs of $32.46.

The in-hospital unit costs were far more variable. Program C, exclusively using the Kiil dialyzer, had an average cost of $34.99, almost double their Kiil home dialysis. Program D, using both Cordis-Dow and Gambro dialyzers, had an average cost of $54.92. Program D's mix was 84% Dow and 16% Gambro. All in-hospital units had an average cost of over $40.00 for supplies. Home training supply costs varied over a range similar to the in-hospital units.

Travel. An often overlooked expense related to the dialysis procedure is the extraordinary expense a patient must bear to seek his or her treatment. Travel of hundreds of miles a week is common for in-hospital, satellite and limited care patients. In addition, patients must episodically travel to the main hemodialysis location for back-up hemodialysis treatment, routine examinations and laboratory tests. Finally, patients in training for home self-dialysis often travel the longest distance to central training centers. Other travel costs included are for dialysis personnel to visit home patients, travel to other centers within their program for surveillance or training and attend professional meetings. The cost of meeting travel was 61 cents per dialysis or less. Table 4 presents the data for travel.

Equipment. Table 5 provides a summary of equipment costs. In general, the amount of equipment necessary to perform a dialysis procedure is relatively standard. While the equipment costs may vary by thousands of dollars, the impact of equipment cost on one dialysis is determined by the length of functional life of the machine for the purpose of this analysis (five years), and the number of treatments necessary per week and per year. The other major cost is the water treatment equipment.

Table 5 indicates, in parentheses for each location, the total cost of owned equipment on a per patient basis, for the home patient group and per bed, for the institutional locations. The data demonstrate that intensive utilization of equipment will lower the cost per dialysis. Compared with the home patient, the effect of increased utilization is appreciable. Although these utilization factors and consequent savings are significant as a percentage of equipment costs, the dollar-cost savings per treatment are small.

Table 5. Equipment: Cost per dialysis in dollars and owned equipment in dollars

	Program				
	A	B	C	D	E
Home patient group	—	9.48	8.43	8.18	11.22
(owned equipment/ person)		(6225)	(6571)	(4130)	(5754)
Limited care unit	1.38	4.40	—	—	3.89
(owned equipment/ bed)	(4321)	(5099)			(10,499)
Satellite unit(s)	—	6.02	6.87	—	7.76
(owned equipment/ bed)	—	(4499)	(7679)		(—)
In-hospital unit	—	—	4.59	3.20	3.35
(owned equipment/ bed)			(11,212)	(5594)	(10,895)
Home training unit	—	9.25	6.39	8.09	8.46
(owned equipment/ bed)		(11,650)	(9059)	(8355)	(5210)

Other expenses. A potpourri of expenses is classified in this "other" object of expense category. These are directly related to the dialysis procedure, but not appropriately classified under the four previous categories. The predominant expenses are laboratory charges, equipment rental, service and maintenance costs, cost for facilities and space and indirect costs. Depending on the administrative relationship be-

Table 6. Other: Cost per dialysis in dollars

	Program				
	A	B	C	D	E
Home patient group					
Direct		0.98	4.70	1.94	6.35
Indirect	—	0	0.83	0.34	2.28
Total		0.98	5.53	2.28	8.63
Limited care unit					
Direct	5.12	20.73			23.97
Indirect	30.01	0	—	—	8.58
Total	35.13	20.73			32.55
Satellite unit(s)					
Direct		23.43	1.07		25.03
Indirect	—	0	19.63	—	30.35
Total		23.43	20.70		55.38
In-hospital unit					
Direct			7.06	37.07	12.80
Indirect	—	—	10.46	1.33	39.65
Total			17.52	38.40	52.45
Home training unit					
Direct		23.83	4.73	36.56	27.50
Indirect	—	0	15.54	2.29	22.92
Total		23.83	20.27	38.85	50.42

Table 7. Total cost: Cost per dialysis in dollars

	Program					Average	Annualized cost
	A	B	C	D	E		
Home patient group	—	33.25	36.59	36.38	66.31	43.13	6,729
Limited care unit	116.18	101.30	—	—	100.22	105.90	16,520
Satellite unit(s)	—	86.71	64.51	—	166.85	NA	—
In-hospital unit	—	—	143.72	160.51	171.51	158.58	24,738
Home training unit	—	146.46	167.13	188.06	258.72	190.09	NA

tween the dialysis program and a parent institution, many of these costs may be included in an indirect fee.

Table 6 shows a summary of costs per dialysis for the "other" expenses. Direct costs are shown as the first entry, while the second entry for each program is its indirect cost. The data show an interesting dichotomy with the home dialysis having a very low "other" cost ($1 to 9) averaging less than $5. All other modalities have "other" costs of $18 to 55 with an average in excess of $30.

Total cost per dialysis. Table 7 indicates the total cost per dialysis in each of the locations for each of the institutions, and is the essence of the study. The data for the various modalities of dialysis are considered to be sufficiently comparable to derive an average cost. The exception is satellite dialysis, which presents divergent methodologies and, thus, must not be averaged.

The average home dialysis cost was approximately $43, equating to an annual cost of just under $7,000. Likewise, limited care dialysis had an average cost of $106 or an annualized cost of $16,500. For the in-hospital program, the average is $159, and for an entire year, its cost would be $24,700. Finally, the most expensive dialysis is, of course, that performed during the home training phase of a patient's home treatment program and had a cost of $190. Depending on the skill of the instructors and the skill of the patient, the number of dialyses required in the home training setting will vary from 9 to 24. Thus, home training costs between $1,711 and $4,560 per patient. Retraining for new equipment or procedures will also cost $190 per treatment.

Discussion

In this study comparative cost data from five comprehensive renal disease treatment programs in a total of 29 settings are presented: four home patient groups, three limited care units, three in-hospital units and four home training units. In addition, three centers operated satellite programs controlling or affiliating with 15 satellite units. Data from the satellite units are grouped together with their parent program.

The results are presented as they were developed by the five centers. With the exception of the physician component, the major costs associated with a dialysis, namely personnel and supplies, were very well-documented by each of the centers. In the opinion of

Table 8. Total cost—proposed definitions: Cost per dialysis in dollars

	Program					Average	Annualized cost
	A	B	C	D	E		
Self care—home	—	33.25	36.59	36.38	66.31	43.13	6,729
Self care—affiliate—out of hospital	—	—	<65	—	—	NA	—
Partial care—affiliate—out of hospital	—	86.71	—	—	—	NA	—
Partial care—affiliate—in-hospital	—	—	>65	—	—	NA	—
Full care—center—out of hospital	116.18	101.30	—	—	100.22	105.90	16,520
Full care—affiliate—in-hospital	—	—	—	—	166.85	NA	—
Intensive care—center—in-hospital	—	—	143.72	160.51	171.51	158.58	24,738
Self-care training—center—in-hospital	—	146.46	167.13	—	—	156.80	NA
Self-care training—center—out of hospital	—	—	—	188.06	258.72	223.39	NA

cost accountants experienced in dialysis units, who administered the study, the results are judged to be within an error of plus or minus 10%.

The new definitions of dialysis modalities offer another opportunity to compare hemodialysis costs, as shown in Table 8, where relationships among costs, dialysis location, involvement of the patient and type of treatment are more clear. In the future, use of the new definitions may enable cost relationships to be interpreted in a more meaningful way as additional data are available.

During the course of the study, many different dialyzers were used. The section on supplies dramatically points out the variability of costs for these dialyzers. Routinely, Kiil dialyzers, requiring only disposable membrane and blood ports, cost approximately $1.25 per dialysis; coils, $15 to 17; and other disposible dialyzers, $18 to 25. The cost of the dialyzer will continue to be an important factor in the cost of hemodialysis. Other dialyzer-related factors such as cost of tubing, associated delivery systems, need for technicians and storage space and the rate of failure all impact the cost picture. Of the limited care units, the coil-using unit had costs significantly higher than the other two which utilized Kiils, where a higher personnel cost was the reason (unique, for usually higher costs are caused by the supplies). For every pair of comparable examples, a Kiil kidney and a proportioning delivery system offered the lowest cost per treatment.

A trend toward shorter dialysis treatment is evident at the five study sites. When the treatment time falls below five hours, and three shifts of patients can be supervised and treated by two shifts of personnel (as is done in some proprietory dialysis units), there may be a financial incentive to use the non-Kiil dialyzer. At present this *financial* benefit does not exist in the programs studied.

Without a reuse protocol the cost of "disposable" dialyzers is a high contributor to dialysis cost. Interestingly, in all cases where it was feasible, the five centers did reuse a variety of dialyzers. Reuse of a dialyzer can save between $10 and $15 per dialysis. Adding blood line reuse could increase the savings by $2 to 4 per dialysis. To estimate potential savings from reuse, one may assume that 50% or more of all dialyses in the United States during 1974 utilized a non-Kiil dialyzer, which could be reused. If one includes all home patients, all satellite patients and a great proportion of the limited care patients, for 15,000 patients on dialysis, the annual savings would be between $12 and $22 million.

Dialysate systems used in the five study locations included the Drake-Willock, the Milton-Roy "B" and "BR", the Travenol RSP and the Cobe Centry. The cost for equipment, while a large capital outlay, does not constitute a major proportion of the cost of individual diaylsis treatment, even in home dialysis. The variation between the least expensive and the most expensive delivery system/dialyzer combination is a small differential in the cost of a single dialysis. A relatively inexpensive system based on the Travenol RSP may cost from $2,000 to $2,600. At the other extreme, there are delivery systems in the $4,000 range such as the Drake-Willock, the Cobe Centry and the Milton-Roy "BR", which with additional equipment may reach $6,000 per unit. The difference of $4 to 5 per dialysis cost would be a small portion of the total cost. In general, the more elaborate machine required for a D-4 Kiil kidney will save enough money in supplies compared to a coil or other disposable kidney during the first 12 to 18 months to pay for the added cost of the equipment. Therefore, selection of dialysis equipment should be a function of its reliability, features of the machine, availability of repair services and parts and its ability to serve the particular patient population, rather than its cost. One place where cost does enter into the equipment purchase decision is in the installation of central dialysate systems. There are significant savings in cost as well as space and technician time by use of a central system.

All of the data contained in this study are presented at the prevailing costs during July through November 1973. Since that time the United States has experienced a high rate of inflation. Inflation has raised salaries and the cost of supplies as well as the cost of other services. Concomitant with inflation has been an increased demand for hemodialysis treatments. Within the scope of this study, no attempt can be made to see how these two forces, inflation and economy of scale, affect the total cost of dialysis. A six-year home dialysis and home training cost study indicated that the treatment costs did not increase from 1967 to 1973 due to economies of scale (Barry Flaer, private communication).

One index that is used to project overall changes in price in the United States is the consumer price index issued by the Bureau of Labor Statistics. Since August, 1973, representing the base of the study, the Medical Care Total Index has increased from 137.6 to 168.1 (June, 1975) [8]. Data from this study can be modified by use of future indices.

The study of a multiplicity of modes for providing dialysis therapy documents dialysis costs in detail and generally confirms earlier data. One must bear in mind that the overall costs for maintenance of a dialysis patient are not represented by the costs

shown here. In addition to the cost of dialysis, as defined in this study, one must add the cost of physician services, blood access surgery, radiology and the cost of treatment of complications including the necessary hospitalizations. Also, allowance must be made for use of more expensive back-up dialyses, when required. This study does provide a detailed view of a spectrum of dialysis costs typical of the United States. The cost differences between home or self-dialysis and limited care dialysis are probably typical of most centers. The importance of personnel costs to the cost of limited care dialysis, and its relation to staffing patterns and dialysis time, is apparent. If adequate therapy can be administered to three shifts of patients with two shifts of personnel, costs can be significantly reduced. A further reduction of dialysis time to the three-hour range, if it can be done without sacrifice of medical quality of treatment, may represent another opportunity for significant savings. This would permit treatments to be completed within four hours overall. In self-care dialysis, supply costs remain the dominant factor, with time of dialysis important to the patient but not to cost. Thus, providing the technical capability for shorter time dialysis is a worthwhile research objective because of the large number of patients who will be maintained by limited care dialysis. A second economically important objective is to develop additional information to enable clinicians to minimize the costly medical complications of long-term dialysis patients.

The applicability of these results to other countries is obviously limited due to possible differences in staffing patterns, salary levels, treatment philosophy and other factors. However, the method of study, such as the use of an expanded chart of accounts, is useful for international application.

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References

1. BLAGG CR, COLE JJ, IRVIN G, MARR T, POLLARD TL: How much should dialysis cost? in *Proceedings, Workshop on Dialysis and Transplanatation,* edited by FREEMAN RB, Washington, D.C., Transactions, ASAIO, 1972, p. 54.
2. DOUGLAS RA: The costs of kidney transplantation and hemodialysis. *Transplant Proc* 5:1043–1046, 1973
3. FLAER B: *Six Year Study of Home Dialysis Training Costs.* Preliminary Report, Kidney Disease Control Program, Regional Medical Program Services, Department of Health, Education, and Welfare, Washington, D.C., 1973
4. HOFFSTEIN PA: *Home Hemodialysis Training Costs, a Progress Report.* Kidney Disease Control Program, Regional Medical Program Services, Department of Health, Education, and Welfare, Washington, D.C., 1969
5. HOFFSTEIN PA: *Low Cost Hemodialysis.* Kidney Disease Control Program, Regional Medical Program Services, Department of Health, Education, and Welfare, Washington, D.C., 1970
6. SIEMSEN AW, ENNIS J, MCGOWAN R, WONG EGC, WONG LMF: Limited care hemodialysis. *Trans Am Soc Artif Intern Organs* 18:70–74, 1972
7. STEWART JH, TOPP ND, MARTIN S, SCHAWROWAS E, FLAUS Y, SCHEIL AGR, MAHONY JF: The costs of domiciliary maintenance hemodialysis: A comparison with alternate renal replacement regimens. *Med J Aust* 1 (4):156–159, 1973
8. Monthly Statistical Report: *Summary of Selected Price, Cost and Utilization Data for the Health Care Market in the United States.* Social Security Administration, Office of Research and Statistics, Division of Health Insurance Studies, July, 1975